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Salinity Measurements and General Condition of Violet Marsh, Post Hurricane Katrina

by Jeff P. Lin and Barbara A. Kleiss

PURPOSE: This technical note reports surface salinity measurements taken in Violet Marsh approximately 3-1/2 months after Hurricane Katrina, and compares them to measurements made in 1993-1994 as part of the Violet Siphon Project. This note also includes photo documentation and general visual observations of the physical condition of the marsh post-Katrina.

BACKGROUND: Hurricane Katrina made landfall at the Louisiana and Mississippi coasts as a Category 3 hurricane on August 29, 2005. Hurricane force winds and associated storm surge caused intensive and widespread flooding and damage to cities and the adjacent coastal marshes. The Violet Marsh is being studied because it was subjected to the effects of hurricane winds, saltwater intrusion from the storm surge topping/breaching the levees, and floodwater being pumped from the city into the marsh. The marsh is also being considered for future restoration efforts.

STUDY AREA: Violet Marsh is located in St. Bernard Parish, LA, between the town of Chalmette and Lake Borgne. The study area (Figure 1) is approximately 31.5 square miles. The marsh is directly connected by the Violet Canal to both the Mississippi River and the Mississippi River Gulf Outlet Canal (MRGO). Two levees border the marsh, the back protection levee along the Forty Arpent Canal at the western edge of the marsh, and the Federal levee along the MRGO at the eastern edge of the marsh. Both of these levees were subjected to hurricane-induced and deliberate breaches.

METHODS: Surface salinity was measured in various transects/areas within Violet Marsh on December 13-14, 2005, using a YSI Model 85 salinity meter. At each sampling station, salinity, water depth, and water temperature were also measured, and photos were taken. Soil cores (30-cm) were also taken at several locations. Sampling stations were located along six general transects or areas within the marsh (Figure 2). Salinities at stations along transect 6 were compared to salinities measured at those same stations during 1993-1994 as part of the Violet Siphon Project (Carriere 1996).



Key points...

What impact did Hurricane Katrina have on Violet Marsh, Louisiana? One indicator of impact is surface salinity, which was measured 3-1/2 months after Hurricane Katrina. Measurements were compared to data collected in 1993-1994 as part of the Violet Siphon Project. Surface salinities increased dramatically between 1993-94 and Hurricane Katrina. At least a portion of this change can be attributed to the hurricane storm surge, which deposited salt water in the marsh. The physical condition of the marsh after Hurricane Katrina is documented in photos and general visual observations.

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Figure 1. Violet Marsh study area

RESULTS AND DISCUSSION:

Transect 1: Transect 1 (Figure 3) is located at the northern end of the marsh and runs north/northeast from the location of Pump Stations 1 and 6 (Fortification and Jean Lafitte). Stations were sampled on December 13, 2005. Table 1 contains the results from this transect.

The area in the vicinity of stations 7-10 showed likely evidence of hurricane damage and effects. The area is currently open water containing many small floating patches of *Spartina sp.* and numerous standing and floating cypress (*Taxodium distichum*) trunks and stumps (Figure 4). Cypressess appeared to have been dead for some time. A soil core taken at station 10 consisted of mostly saturated muck and undecomposed organic material with little clay present.

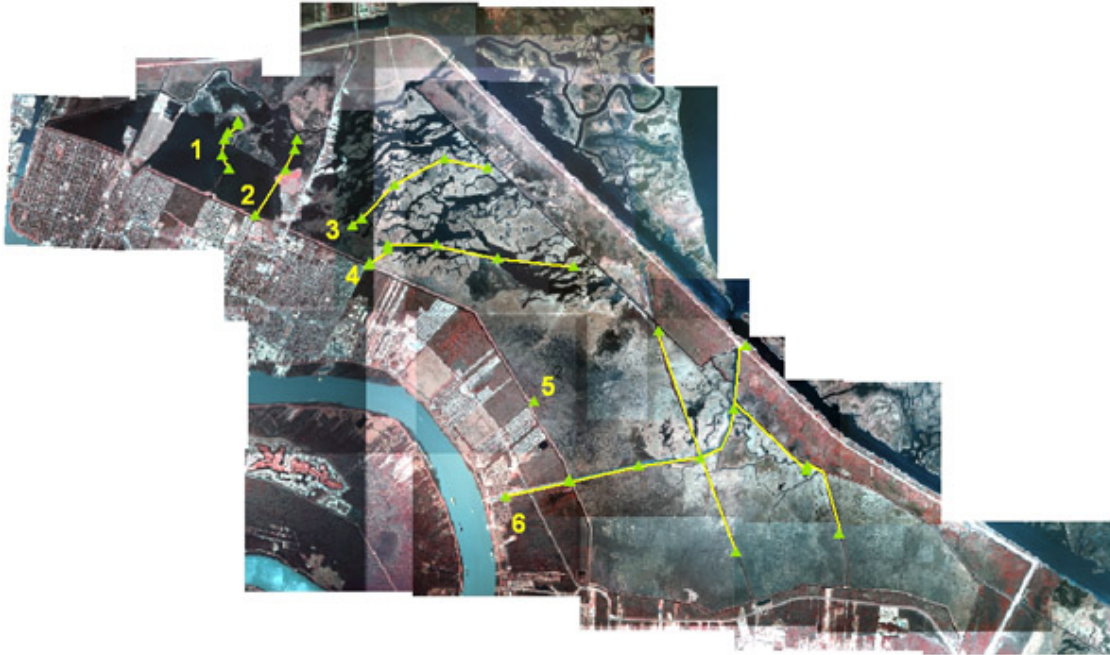


Figure 2. Transects/areas where sampling stations (indicated by the green triangles) were located

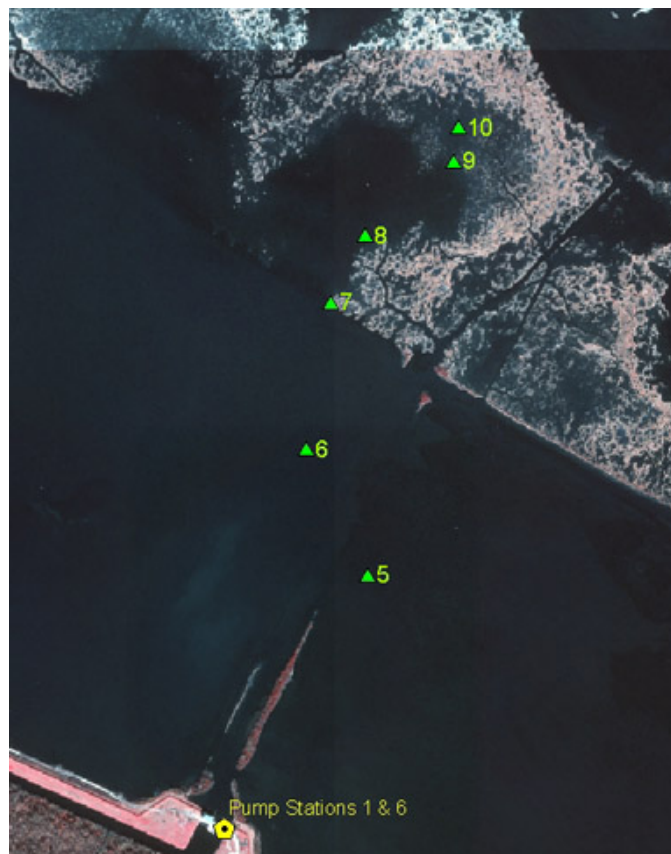


Figure 3. Transect 1 sampling locations (green triangles)

Table 1 Transect 1 Data			
Station	Water Depth, cm	Surface Salinity, ppt	Water Temp., °C
5	63	11.4	12.3
6	86	11.4	12.0
7	15	11.0	12.3
8	11	11.2	12.9
9	8	12.6	15.2
10	4	9.3	15.5



Figure 4. Station 9, facing north, showing *Spartina* patches, cypress stumps, and floating woody debris

The presence of dead cypress trees indicates that this area was at one time more of a freshwater environment. While inter-species variations in saltwater tolerance exist, most cypress seedlings are tolerant of salinities around 2 ppt (Allen et al. 1997), while current salinities in this area were on average approximately 11 ppt. Although the cypresses in Violet Marsh were already dead pre-Katrina, it is likely that the hurricane further increased salinities in this area. These high salinities would likely prevent the establishment and growth of new cypress seedlings during any restoration effort.

Transect 2: Transect 2 (Figure 5) is located at the northern end of the marsh and runs north/northeast from the location of pump station 2 (Guichard). Stations were sampled on December 13, 2005. Table 2 contains the results from this transect, which passes primarily through an open water area. There are large broken patches of *Spartina* in the area of station 3 (Figure 6). A soil core taken at station 1 consisted of a mixture of clay and undecomposed organic material (Figure 7).



Figure 5. Transect 2 sampling locations

Table 2			
Transect 2 Data			
Station	Water Depth, cm	Surface Salinity, ppt	Water Temp., °C
1	21	10.8	11.9
2	65	10.8	11.3
3	8	10.8	12.2
4	36	11.6	11.9



Figure 6. Station 3, facing south



Figure 7. 30-cm soil core taken at station 1

Transect 3: Transect 3 runs north/northeast through Bayou Villere, across the central part of Violet Marsh (Figure 8). Stations were sampled on December 14, 2005. Results from this transect can be found in Table 3. Along the Bayou Villere, the marsh is relatively unbroken, with no obvious visual evidence of hurricane damage or effects. However, the area southwest of Bayou Villere (stations 35 and 36) does show some signs of damage. A soil core taken at station 36 consisted mostly of undecomposed organic material with some clay (Figure 9).



Figure 8. Transect 3 sampling locations

Table 3			
Transect 3 Data			
Station	Water Depth, cm	Surface Salinity, ppt	Water Temp., °C
32	15	11.7	13.0
33	>100	11.5	13.2
34	90	11.8	13.2
35	55	11.8	13.6
36	19	11.8	14.2



Figure 9. 0-cm soil core taken at station 36

Transect 4: Transect 4 (Figure 10) runs east from Pump Station 3 (Bayou Villere) across the central portion of Violet Marsh. Stations were sampled on December 14, 2005. Table 4 contains the results from this transect. Measurements indicate an incremental increase in salinity at each station moving east from Pump Station 3 towards the MRGO. The marsh was relatively intact near the MRGO (Figure 11), but shows some evidence of damage closer to back protection levee (Figure 12).



Figure 10. Transect 4 sampling locations

Table 4			
Transect 4 Data			
Station	Water Depth, cm	Surface Salinity, ppt	Water Temp., °C
11	46	9.2	15.0
26	17	12.1	12.2
27	28	11.0	13.0
28	48	10.2	13.3
29	31	9.0	13.3
30	34	9.0	13.5
31	68	8.8	13.1

Transect 5: Transect 5 (Figure 13) contains a single station, located at pump station 4 (Meraux) in the west-central portion of Violet Marsh. The station was sampled on December 13, 2005. Results can be found in Table 5. Of all the sampling stations, station 12 had the lowest salinity measurement.

Transect 6: Transect 6 (Figure 14) contains most of the sampling stations used to monitor the Violet Siphon Project. Most of these stations were located along various canals in the southern portion of Violet Marsh, with the majority being inside the Violet Canal.

The purpose of the Siphon Project was to reintroduce freshwater from the Mississippi River into the marsh in order to counteract the increase in salinity and the intrusion of saltwater brought about by the construction of the Mississippi River levee and the opening of the MRGO. Salinity was monitored biweekly from January 1993 to February 1994. The siphon was operational for 7 months during the 13-month monitoring period. The full Violet Siphon project monitoring reports are available online at: http://sonris.com/direct.asp?path=/sundown/cart_prod/cart_bms_avail_documents_f (search for project PO-01). Monitoring results indicated that the siphon had no significant effect on mean salinities other than at the three stations closest to the siphon itself. The siphon is currently no longer operational.



Figure 11. Station 26, facing north, showing intact marsh



Figure 12. Station 29, facing southwest, showing broken-up area of marsh



Figure 13. Transect 5 sampling locations

Table 5			
Transect 5 Data			
Station	Water Depth, cm	Surface Salinity, ppt	Water Temp., °C
12	41	7.1	15.8

Table 6 compares salinities measured at these stations on December 14, 2005 with mean salinities ± 1 SE measured at the stations from January 1993 to February 1994 (during periods the siphon was non-operational), and reported in Violet Siphon Progress Report No. 2 (Carriere 1996). Most of the salinity data in the progress report are given in the form of a bar graph with limited demarcations. Therefore, the 1993-94 salinities reported in Table 6 are not precise data, but best estimates based on interpretation of the bar graph. Also, the 1993-94 monitoring effort measured both surface and bottom salinities, but the progress report is not clear as to which number is being reported, or if an average of the two is used.

The 2005 salinity measurements appear to be fairly consistent across all sampling stations, although stations 21 and 25 had somewhat higher readings than the rest. Unexpectedly, there was not a consistent decrease in salinities going west from the MRGO to the Mississippi River through the Violet Canal. In fact, the lowest salinity reading was at station 17 at the mouth of the MRGO. With the exception of station 17, the current salinities at every station are markedly higher than the corresponding mean salinity from 1993-1994, even when factoring in the standard error.

The marsh throughout this transect area appeared to be fairly intact (Figure 15). A soil core taken at station 24 consisted of highly reduced clay with very little noticeable organic matter.

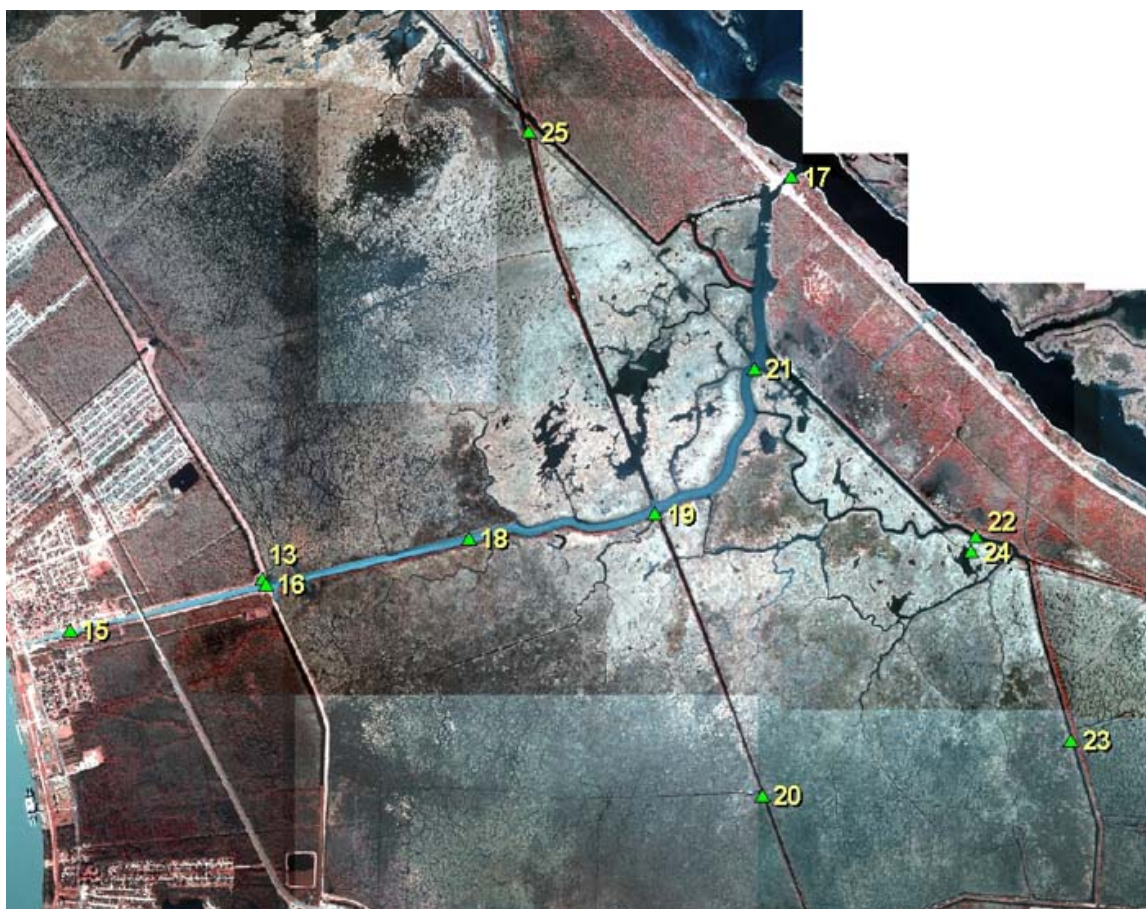


Figure 14. Transect 6 sampling locations

Table 6
Transect 6 Data for 2005 Compared to 1993-94 Monitoring Data
During Periods the Violet Siphon was Non-operational. Stations
were numbered differently in 2005 than in 1993-94

2005 Station	2005 Water Depth, cm	2005 Water Temp., °C	2005 Surface Salinity, ppt	1993-94 Station	1993-94 Mean Salinity (ppt) +/- SE
13	-	15.8	12.0	-	-
15	>100	14.6	12.4	1	3.3 +/- 0.7
16	>100	13.8	12.2	2	4.9 +/- 1.3
17	>100	12.1	11.4	7	10.0 +/- 2.2
18	>100	12.1	12.1	3	5.8 +/- 1.3
19	>100	11.8	12.8	4	8.5 +/- 1.8
20	90	12.5	12.4	20	8.0 +/- 1.3
21	>100	11.8	14.3	5	9.8 +/- 2.3
22	>100	11.8	12.9	-	-
23	>100	12.6	12.5	21	6.7 +/- 1.5
24	13	12.5	12.5	6	8.0 +/- 1.7
25	>100	12.6	14.4	8	9.0 +/- 2.0



Figure 15. Station 18, facing north

CONCLUSIONS: Surface salinities, as measured in the Violet Canal and areas in the southern portion of Violet Marsh, appear to have increased markedly since 1993-94. At least part of this increase can most likely be attributed to the 17- to 18-ft hurricane storm surge (Figure 16) topping/breaching the MRGO levee (Figure 17) and depositing a large amount of salt water into the marsh. No older data were found with which to compare current salinity measurements in other areas of the marsh, but salinities have most likely increased there as well post-Katrina.

Current salinities across the entire marsh were fairly consistent, ranging from 7.1 to 14.4 ppt (mean = 11.4 ppt, SD = 1.5 ppt). Across open-water areas of the marsh (transect 4) there was an incremental increase in salinity moving east from the back protection levee towards the MRGO. However, this pattern was not obvious when going east through Bayou Villere or the Violet Canal.

The northwestern portion of the marsh (Transects 1 and 2, and Transects 3 and 4 closer to the back protection levee), where there were numerous broken patches of *Spartina* sp., and in some areas, large woody debris, showed the most evidence of possible hurricane damage. Elsewhere, the marsh still appeared to be fairly intact.

ADDENDUM: On 15 February 2006, salinities were measured again at four of the stations. The results are shown in Table 7. As might be expected, salinities have decreased slightly 2 months after the original sampling (approximately 5-1/2 months post-Katrina), but are still relatively high.

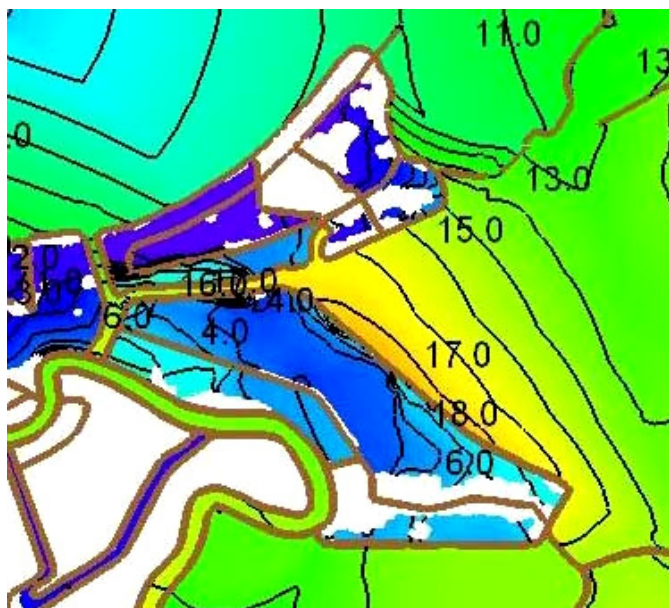


Figure 16. Preliminary ADCIRC model showing maximum 17- to 18-ft storm surge along the MRGO levee



Figure 17. Photo of one of the breaches along the MRGO levee

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Table 7		
Comparison of Salinities on 12/13-14, 2005 and 2/15/2006 at Four Sampling Stations		
Station	Salinity (ppt) 12/13-12/14, 2005	Salinity (ppt) 2/15/2006
2	10.8	10.3
3	10.8	10.4
28	10.2	10.1
29	9.0	7.1

Lin, J. P., and Kleiss, B. A. (2006). "Salinity measurements and general condition of Violet Marsh, Post Hurricane Katrina" EL Technical Notes Collection," *Environmental Lab Technical Note* (ERDC/EL TN-06-1). U.S. Army Engineer Research and Development Center, Vicksburg, MS. <http://el.erdc.usace.army.mil/>

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- Carriere, J. (1996). "Violet Siphon (PO-01) Progress Report No. 2." Report PO-01-MSPR-0396-2. Louisiana Department of Natural Resources, Coastal Restoration Division, Baton Rouge, LA.

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